Advancing Spray drift Deposition Assessment: Comparing Modelling and Measured Data for Regulatory Risk Assessment of Plant Protection Products in Arable Crops

Minutes of the meeting

15-16 April 2024
12:00-17:15 / 8.30- 18:30
Minutes 19 April 2024

EUROPEAN FOOD SAFETY AUTHORITY

Location: Workshop in Wageningen, Netherlands

Attendees:

- Network Participants:

Country	Organisation
Belgium	Federal Public Service Health, Food Chain Safety and Environment
Czech Republic	Central institute for supervising and testing in agriculture
Denmark	DEPA
Estonia	Plant Protection and Fertilisers Department
Finland	Finnish Safety and Chemicals Agency (Tukes)
France	ANSES
Germany	Federal Environment Agency (UBA)
Italy	International Centre for Pesticides and Health Risk Prevention (ICPS)
Italy	Italian Ministry of Health (ENEA)
Lithuania	The State Plant Service under the Ministry of Agriculture
Netherlands	CTGB
Norway	Norwegian Food Safety Authority
Poland	E-V-A Sp. z o. o. – Warsaw
Slovenia	Administration of the Republic of Slovenia for Food Safety, Veterinary Sector and Plant Protection, Plant Protection Products Division
Spain	INIA-CSIC

- EFSA:
  PLANTS Team Chemistry and Environmental Exposure: HERRERO NOGAREDA Laia; PADOVANI Laura

  PLANTS Team Ecotoxicology: FERILLI Franco, SZENTES Csaba

- Other stakeholders representatives invited by Wageningen University and Research (WUR)[1]:
  - BASF
  - Bayer Crop Science

[1]WUR participated in the organisation of the workshop, as this "stakeholders engagement event" was part of the activities outlined in the second Specific Agreement of the Framework Partnership Agreement FPA GP/EFSA/PREV/2020/02 between WUR and EFSA.

- BeeLife European Beekeeping Coordination
- European Commission (DG SANTE)
- FMC Corporation
- INRAE
- Julius Kühn-Institut (JKI)
- Silsoe Spray Applications Unit (SSAU) Ltd
- University of Torino, Department of Agricultural, Forest and Food Sciences (DiSAFA)
- Wageningen University and Research (WUR)

1. Welcome and apologies for absence

The Chair welcomed the participants.
Apologies were received from Poland (one representative out of two).

2. Adoption of agenda

The agenda was adopted without changes.

3. Background info on measuring spray drift deposition in arable crops across the EU

This session delved into the current practices of measuring and utilizing spray drift deposition in arable crops across the EU. It featured presentations from experts in France and Italy, highlighting methods employed in each country.

In the **French CAPRIV project**, drift was measured using a comprehensive approach that involved:

- Development of a harmonized methodology for measuring drift, ensuring consistency and comparability across different studies and locations.
- Identification of potential strategies to reduce drift, including technological innovations and changes in agricultural practices.
- Evaluation of the effectiveness of physical barriers, such as vegetal hedges, in mitigating drift and protecting sensitive areas.
- Modelling of short-range airborne transport of drift to assess its movement beyond cropping areas and its potential consequences.

Three interpretations of drift transported in the air beyond the cropping area were considered:

1. Drift deposited on the ground (referred to as "sedimentary").
2. Drift crossing a vertical plane (termed "aerial").
3. Drift deposited on the surface of bodies (referred to as "dermal/manikins").

Two fluorescent tracers, Brillant Sulfaflavine (BSF) and Sulforhodamine B (SFR-B), were tested in the project. While BSF showed promising results, challenges were encountered with its extraction on cotton t-shirts, potentially leading to measurement errors with manikins. SFR-B emerged as a more favourable alternative due to its improved extraction on cotton and overall stability.
The project observed various drift behaviours, including sedimentary and aerial drift cases, both with and without the presence of hedges. Additionally, the utilization of artificial wind in viticulture was explored as part of the CAPRIV project.

The second presentation of this session discussed the disparity in drift experimental trials between arable crops and vineyard/orchard contexts in Italy over the past two decades. This discrepancy stemmed from higher levels of spray drift observed in three-dimensional (3D) crops compared to arable crops, along with heightened public concerns about drift in 3D crops often located near or within urban areas. **Field experimental trials conducted by the Italian DISAFA – UNITO** were highlighted, focusing on methodologies and challenges faced. Trials from 2007 and 2018 were examined, detailing the type of tracers used, collector types, sprayer speeds, and layout of experimental fields. Considerations regarding wind conditions, collector placement, and the need for ample field space were discussed, emphasizing the complexities involved in ensuring accurate and reliable trial results.
The development of ISO 22401 was introduced as a means to measure potential drift and provide a standardized framework for comparing sprayer performance. An example calculation of the Drift Potential Value (DPV) and classification of candidate sprayers versus reference sprayers using DPV were presented.
Future challenges were outlined, including the need to further study the correlation between field and indoor results using test benches, to predict ground drift deposits based on DPV. Additionally, exploring airborne drift from field crop sprayers was identified as an area for future investigation.

4. How is measured spray drift deposition used in the present RA of NTTOs?

This session provided an overview of **current regulatory practices** for non-target arthropods (NTA) and non-target terrestrial plants (NTTP) in arable crop contexts, focusing primarily on exposure assessment, particularly spray drift. Basic principles of NTA risk assessment were discussed, including in-field and off-field exposure evaluations based on hazard quotient (HQ) calculations.
The main emphasis of the presentation was on the off-field area, referencing key reports and guidelines such as SETAC ESCORT 2, ESCORT 3, and OECD test guidelines. Test methodologies and endpoints for NTA and NTTP were outlined, along with exposure assessment parameters, specifically spray drift deposition.
Differences in evaluation zones and mitigation strategies between EU/CZ and NL were highlighted, including the use of Ganzelmeier/Rautmann drift data at the EU level and the Dutch drift database/WDC tool at the national level. Mitigation measures such as no-spray zones and drift-reducing technologies (DRT) were discussed in the context of reducing spray drift.
The presentation concluded by acknowledging the limitations of the current EU drift approach and the need for further harmonization efforts. Discrepancies between

datasets and evaluation methodologies were noted, underscoring the importance of refining regulatory practices to ensure accurate assessment of spray drift impacts.

5. Defining off-target areas for protecting NTTOs

This session highlighted the absence of harmonization regarding the **definition of exposure areas for drift deposition** to protect non-target terrestrial organisms (NTTOs). It emphasized the varying perspectives within the EU regarding off-crop areas and the lack of clear definitions, leading to confusion and inconsistent practices. The main objective was to provide clear definitions for different areas where NTTO protection is required, specifically in-crop, in-field off-crop, and off-field areas. It highlighted the importance of distinguishing between in-field and in-crop areas and proposed distinct protection levels for each. Proposed definitions included the delineation of three exposure evaluation strips/areas corresponding to in-crop SPGs (Specific Protection Goals), in-field off-crop SPGs, and off-field SPGs. This lack of harmonization poses challenges for risk assessment and regulatory decision-making, as it makes it difficult to ensure consistent protection levels for NTTOs across different regions and agricultural practices. It was emphasized that the selection of a specific protection level is ultimately a decision made by risk managers: while regulatory guidelines may provide frameworks and requirements for risk assessment, the actual determination of the protection level for each area, such as in-crop, in-field off-crop, and off-field, rests with the risk managers.

Additionally, it was highlighted the significance of accurately specifying the starting point (x=0) for spray drift measurement, whether it be at the crop edge, centre of the last row, or last nozzle position.

In summary, the presentation emphasised the need for explicit definitions of SPGs and exposure evaluation strips for different areas to ensure effective protection of NTTOs from spray drift deposition.

6. Using modelled estimates of spray drift deposition instead of direct measurements

This session collectively addressed the key steps and elements of the FPA project conducted by WUR. It was highlighted the pressing need for accurate models to assess spray drift deposition near treated fields, with a particular focus on the procedure for utilising experimental spray drift data to validate model accuracy, identifying any discrepancies between model predictions and actual data, and iteratively refining model parameters to improve predictive capabilities.

Key aspects included:

Model Inventory and Evaluation: The model inventory process involved conducting a thorough literature search to identify existing spray drift models suitable for assessing pesticide exposure risk near treated fields. Different types of models, including mechanistic, empirical, and specialized ones like Gaussian plume models, were considered. Criteria were established to evaluate each model's suitability based on factors such as its applicability to arable crops, compliance with EU regulatory standards, and validation against experimental data. The search started with a broad exploration of literature databases to compile a longlist of relevant publications, which was then refined to a shortlist of potentially suitable models. Experts were consulted to ensure the inventory captured a comprehensive range of models available in the scientific community. The final shortlist included models like AGDRIFT, CASANOVA, IDEFICS, and SSDM, which showed promise in meeting regulatory requirements and accurately predicting spray drift deposition. In the FPA project led by WUR, the choice to use the IDEFICS model for comparison with experimental data was primarily based on familiarity and accessibility.

SETAC DRAW spray drift database: The SETAC DRAW database was presented. This database is a comprehensive repository of spray drift experiment data collected from various sources such as academic research, industry-sponsored trials, and regulatory studies. It encompasses data from a wide range of spray drift experiments conducted across different geographical regions and under varying environmental conditions. The database includes data on both sedimenting drift (deposition onto horizontal surfaces) and airborne drift (profiles of spray particles in the air). Detailed analyses were conducted to identify key factors influencing drift variability and explore regulatory scenarios. According to this analysis, 40% of the overall variability in spray drift observations is "country specific" (i.e. the variability in the drift data can be attributed mainly to factors unique to each country). By considering parameters such as forward speed, wind speed, and application pressure, the presentations aimed to anticipate future trends and inform regulatory decision-making.

Evaluation Protocol for Field Data: The evaluation protocol for field data to test the IDEFICS model involved several steps. First, clear criteria were established for evaluating field trial datasets based on factors like experimental setup, data quality, and relevance to the model's scope. Then, these criteria were applied to select datasets that meet the protocol's requirements, excluding those that do not comply. Once the datasets were selected, their reliability and completeness were verified, ensuring they provide sufficient information on key parameters and experimental conditions. Any missing parameters were addressed through appropriate estimation techniques while maintaining data integrity.

7. Highlights of Day 1 by EFSA + closure of day

The main considerations from Day 1 were:

- Recognising the importance of harmonising methodologies and protocols for measuring spray drift deposition to ensure consistency and comparability across different studies and locations.
- Recognising the need to delineate specific protection levels for each area and clarifying the starting point (x=0) for spray drift measurements.
- Emphasizing the importance of harmonizing definitions (e.g. in-field off-crop strip) and standards across EU member states to avoid confusion and inconsistency in regulatory practices related to spray drift assessment and mitigation.

- Recognising the importance of an extensive database of empirical data covering various aspects of spray drift research, including different crop types, application methods, nozzle types, sampling methods (e.g. sedimentary, aerial), environmental conditions, and experimental protocols. By analyzing this data, researchers can identify trends, patterns, and factors influencing spray drift deposition. This empirical evidence serves as the basis for developing and validating predictive models.
- Acknowledging that spray drift is a complex phenomenon with significant variability and uncertainty. The goal is to address this complexity through advanced modeling techniques while acknowledging the limitations of the available data and the need for ongoing validation.
- oThe current situation was summarized by highlighting that mechanistic models simulating spray drift from arable crops, as well as data of measured deposition values exist, and methods to combine the data with the models is being exploded. Therefore, further calibration/validation of models could be conducted to explore further their potential utility in a regulatory context.

8. Models for simulating spray drift deposition

This session featured presentations on three notable models for simulating spray drift deposition in arable crops: the IDEFICS model, the SSDM model (or SiMoD) and the Casanova model. Each presentation provided insights into the capabilities and applications of their respective models.

The presentation outlined the **IDEFICS model** for deposition in arable crops, which employs a mechanistic particle tracking model to describe the paths of drops through air until they settle. It calculates downwind deposits to the ground and airborne emissions of spray drift for conventional boom sprayers in arable crops, considering factors like in-flight evaporation of droplets and various adjustable parameters related to the field, sprayer, and environment.

Key parameters in the IDEFICS model include field-related factors such as crop height and density, sprayer-related factors like height above crop and nozzle selection, and environmental factors such as wind velocity, turbulence, temperature, and humidity. Special features of the model include the consideration of entrained air, which affects the trajectory of droplets, and in-flight evaporation, influenced by temperature and relative humidity.

IDEFICS simulations involve numerical settings for full-field spray application, with droplets' paths simulated from multiple nozzle positions and considerations for ground deposits and airborne emissions. The model was validated via experiments involving a range of variables such as sprayer boom height, nozzle type, liquid pressure, driving speed, and environmental parameters, with comparisons made to full field trials to assess accuracy.

Future developments include revalidation using more validation trials focusing on factors like crop heights and forward speeds, validating airborne emissions, and incorporating drop size distributions measured using techniques like PDPA and Shadowgraphy. Additionally, efforts are underway to model deposition variation due to sprayer boom movements using the 3D feature of IDEFICS.

The **SiMoD** (Silsoe Model of Drift) is a comprehensive model for assessing spray drift from agricultural sprayers. Its history dates back to the 1980s, with notable contributions from researchers like Thompson, Ley, Miller, Hadfield, and Butler Ellis. The model's concept revolves around a particle trajectory approach, simulating the path of individual droplets and considering various environmental, sprayer, and vegetation parameters. SiMoD's capabilities include accommodating different hydraulic nozzles and pressure/flow rates, as well as sprayer parameters like speed, boom height, and sprayed swath width. It outputs ground deposits and airborne spray over a user-defined grid, taking into account wind speed and vegetation characteristics. Validation efforts have involved comparing the model with field data from different regions and experimental setups, including comparisons with UK and US datasets. Recent validations have focused on airborne spray near the ground and external direct dermal exposure from boom sprayers.

Current uses of SiMoD include assessing bystander exposure and serving as the basis for models like BREAM and BROWSE, which predict exposure to non-target species. Future potential includes adapting the model for precision application techniques, such as patch spraying, and introducing additional variables for more accurate predictions. Drift experiments conducted in Poland have provided data for validating the model's predictions. These experiments involve single and overlapping patches, with measured data compared against SiMoD's predictions to assess its accuracy.

The **Casanova Drift Model** (CDM) is a Lagrangian model designed to track individual spray droplets in space and time for arable crop boom sprayers. It incorporates various parameters such as spray angles, droplet spectra, wind velocity profiles, and environmental conditions to simulate spray drift accurately. Key features of the CDM include its ability to simulate different spray angles and applied volume shapes, account for evaporation effects, and handle changes in droplet spectra across the distributed volume. It runs efficiently, taking less than a second per run, and can be operated via a web browser or command line. The model makes simplifying assumptions to enhance computational efficiency, such as assuming equal flow streamlines and ignoring certain turbulence factors. It also provides extensive flexibility for input file editing and allows for the incorporation of different nozzle libraries and formulation effects. From a regulatory perspective, the CDM allows for manual parameter input and editing and provides access to existing nozzle libraries. Researchers can use the model to explore formulation effects and internal specifications, while trialists can set up trials covering various environmental and trial plans. Calibration and validation of the CDM are ongoing projects, aimed at reducing the need for expensive field trials. It has been calibrated against US and EU trial data, showing good predictive matching against US data but requiring further refinement for EU data. Future enhancements include incorporating turbulence models, adding vertical spray components, and making the model open-source for global improvements.

9. Comparison of IDEFICS simulations and measured deposition across EU [not NL]

The presentation focuses on comparing field data with model data from the IDEFICS model, aiming to assess its suitability for regulatory purposes. The study involves a preliminary comparison with a selected spray drift data across five European countries: Denmark, France, Italy, Poland, and the Netherlands. Each country conducted multiple trials with varying replicates and downwind distances, capturing spraying conditions, including nozzle type, liquid pressure, and droplet spectrum, as well as meteorological conditions like wind speed and direction, relative humidity, and temperature. Three approaches were employed for comparison: Root Mean Square Error (RMSE), ratio of simulated to measured drift, and an overview of comparison results. The analysis revealed discrepancies between experimental and simulated data, influenced by factors like wind speed, relative humidity, and wind direction. The main discrepancies observed include overestimation at high wind speeds, underestimation at very low wind speeds, and deviations in wind direction beyond tolerable limits. Additionally, higher crops presented potential limitations due to increased turbulence and canopy interception.

In conclusion, while the IDEFICS model shows the ability to simulate drift under different conditions, it exhibits limitations under extreme weather conditions and with higher crops. Future perspectives include addressing identified limitations, analysing model behaviour, and combining modelling with experimental needs for protocol development. Further steps involve reproducing the comparison with other existing models, identifying complementarity, and aligning with regulatory objectives.

10. Discussion sessions

This session focused on discussing key issues related to spray drift deposition assessment.

Overarching Goal: To exchange ideas and discuss issues related to current and future approaches to spray drift deposition assessment.

Specific Objectives:

- Identify the strengths and weaknesses of the current EU regulatory approach.
- Increase awareness about available spray drift models for regulatory Environmental Risk Assessment (ERA) and their significance.
- Provide suggestions and recommendations for estimating spray drift depositions in habitats adjacent to treated fields.
- Achieve consensus on the definition of relevant terms and concepts within exposure scenarios for Non-Target Terrestrial Organisms (NTTOs) in pesticide risk assessment.
- Explore needs and preferences regarding the content and calculation methods of spray drift deposition in regulatory exposure and risk assessment.

Points Not Covered:

- Detailed discussion on field test design.

- Risk mitigation measures and drift reduction strategies.
- Considerations on human health effects.
- Cumulative effects and synergistic interactions of multiple chemicals used in agriculture.

Process:

Breakout groups: 5 groups (each group with 1 pre-selected Rapporteur), 3 rounds.

Discussion topics:

- Current EU regulatory approach
- Definition of spray drift deposition strips/areas
- Mechanistic spray drift modelling.

The discussion's outcomes were captured collectively by the participants on templates focusing on the above questions.

11. Discussion wrap-up

The breakout session's outcomes were reported by each Rapporteur's group in a plenary session with all participants.

1. *What are the pros and cons of the current EU regulatory approach to estimate off-field spray drift depositions to be used in the RA of NTTOs?*

The current EU regulatory approach for estimating spray drift deposition for Non-Target Terrestrial Organisms (NTTOs) offers certain advantages, notably its simplicity and ease of implementation. However, it also presents notable drawbacks. Participants emphasized the limitations of the Ganzelmeier tables in providing accurate and reliable data for assessing off-field exposure via spray drift across the EU.. It was recognized the challenges of extrapolating data across diverse environments, and strategies for harmonizing measurement practices. While acknowledging the simplicity of the current framework, it was noted that it lacks sophistication, particularly in its reliance on precautionary drift representation curves derived primarily from German drift trials, which may not adequately represent other agro-environmental conditions in the EU. Regional variations in agricultural practices and policies are not adequately addressed, and country-specific conditions may be overlooked. Furthermore, the framework's limited ability to refine exposure assessments, coupled with potential gaps in considering airborne drift, may result in underestimated risks. As a result, there was a shared desire among participants to develop worst-case exposure scenarios akin to the existing FOCUS scenarios, either on a pan-European scale or, at the very least, standardized at the EU zonal level.

2. *What are the key considerations and criteria for defining exposure strip/areas relevant for NTTOs in pesticide risk assessments?*

Rapporteurs of the breakout groups outlined the factors and parameters essential for defining exposure strip areas, encompassing considerations such as proximity to treated fields and habitat characteristics. Emphasis was placed on the necessity for standardised definitions. Firstly, the distinction between the crop edge and the field edge is crucial, along with methodologies for delineating these areas. The determination of which protection goal to employ for a particular area may be influenced by its intended use and makeup. Factors such as whether the area is predominantly natural or cultivated, the specific types of vegetation present, and the results of a cost-benefit analysis all contribute to this decision-making process. The challenges of integrating spatial variability and uncertainty into exposure assessments were also highlighted. Overall, there was a consensus on the desirability of a risk assessment framework that strikes a balance between comprehensiveness and manageability, avoiding unnecessary complexity.

3. *What criteria should be considered when selecting suitable models for simulating spray drift deposition in habitats adjacent to treated field*?

Several criteria were considered important when selecting suitable models for simulating spray drift deposition in habitats adjacent to treated fields:

- should transparently communicate the underlying assumptions and methodologies, allowing stakeholders to understand and assess their validity
- should be applicable across diverse geographical regions, taking into account variations in environmental conditions, crop types, and agricultural practices
- should undergo rigorous calibration and validation against datasets to ensure their reliability and accuracy in predicting spray drift deposition under various scenarios
- should prioritize simplicity by effectively addressing short-range situations rather than attempting to encompass every possible scenario
- should differentiate between sedimenting spray drift, which is relevant to the risk assessment e.g. for in-soil organisms, and airborne spray profiles, which are relevant to assessing exposure for non-target terrestrial plants. Depending on the complexity and specificity of each scenario, it may be necessary to use separate models tailored to each habitat type.
- transparency and openness are key principles to prioritise in model selection. Opting for open-source models promotes collaboration and peer review, enhancing the credibility and trustworthiness of the simulation results.

12. Visit to the spray drift laboratory and demonstration of measuring spray drift deposition

The participants had a unique opportunity to observe a simulated trial focused on spray drift deposition measurements in the field. This experience provided valuable insights into the practical aspects of conducting research in this field. Additionally, they had the chance to learn about the laboratory systems and equipment used for analysing the collectors obtained during the field research, offering a comprehensive understanding of the entire process from data collection to analysis.

Moreover, the session included discussions on advanced spraying systems aimed at improving pesticide efficiency and reducing spray drift. One notable example highlighted was a boom sprayer equipped with a variable-rate algorithm. This algorithm allows the sprayer to adjust the spray volume in real-time based on the specific characteristics of the canopy, such as dimensions, shape, and leaf density. This adaptive approach ensures that the right amount of pesticide is applied precisely where it's needed, optimizing effectiveness while minimizing environmental impact.

Furthermore, participants were introduced to laboratory equipment used to measure droplet size and size distribution.